Emily Roarty **12/10/2015**

Advisor Dr. John Messner

Mapping Utilities using BIM and GIS

Independent Study Report

Introduction

This independent study explores the integration of BIM (Building Information Models) and GIS (Geospatial Information Systems) data to document the location of utilities. Instead of contractors "going in blind" without information on the utilities, 3D maps allow for contractors to accurately coordinate utilities on site. The safety, schedule, and monetary aspects of construction can be improved with a utility BIM and GIS map. In terms of safety, contractors can visualize a more accurate picture of the utilities preventing the tapping of dangerous lines. In terms of schedule, the project goes faster when there is an accurate picture of the objective, in this case the specific utility to repair. Finally financial savings can be achieved if the contractors avoided repairing damaged lines.

In this paper, the literature review discusses the current use of these models in industry. There are two technical sections which discuss the ability to obtain terrain information and then how to geolocate the pipelines on to the terrain. At the end there is an Appendix A with images of the final geolocated map.

LITERATURE REVIEW

As a construction project progresses, the availability of information increases; however, the ability to make changes to the project decreases. By using tools like BIM and GIS to visualize the building and site, one is able to make more informed choices about the project earlier in the construction process (BIM Hub 2015). BIM allows for a more accurate depiction of the building, while GIS allows for a better picture of the site usually in 2D.

Currently in industry 2D GIS and CAD maps are the method of storing utility information. Counties, owners, and facilities management representatives store information in 2D GIS and CAD maps for the utility data. This utility information is limited by its ability to view clashes only in 2D. Most MEP contractors are responsible within five feet of the building to

tap into the utilities. Currently there is a gap in between coordination with utility and MEP contractors.

This paper explores the integration of BIM and GIS models to visualize the building and site in 3D. An integrated BIM and GIS model would be classified as a linkage model (BIM ThinkSpace 2015). The use of the model is to map the underground utility and to visualize how they tie into the building. These integrated BIM and GIS maps can be useful because they could detect clashes between sewage, water, tree roots, electrical, and other lines. These models could also provide resolution to space conflicts on site (Bansal 2011).

Some of the current issues facing BIM and GIS coordination include inaccurate existing information and limited technology. To map the underground utilities the model coordinator is pulling utility information that is older and sometimes inaccurate. Ground penetrating radar is able to detect that something is there, but it cannot determine if it is an electrical line or concrete. At times the process involves a little guesswork to determine the historical utilities on site. Sometimes information is only stored in 2D maps and have trouble converting into 3D maps with varying terrain.

Some of the current solutions to track utilities consists of mapping 2D GIS and CAD maps. However none of these solutions propose an up to date 3D visualization or make use of a building model. In *Computing in Civil Engineering 2015*, the article explored how Building Information Modeling and Geospatial Information Systems will be integrated to create an accurate depiction of the utilities on site. The goal of this paper is to have an up to date utilities model to assist with coordination on site.

In the future, software that integrates BIM and GIS is going to improve. The advantage to using both BIM and GIS is that one can visualize the site in its entirety, including trees, electrical lines, sewage lines, etc. Having a site model helps communicate to the entire project team the existing utilities. According to the MAP-21 Bill that was passed, infrastructure projects are going to be required to have these types of coordinated site maps. According to " BIM vs. GIS" in 2015, BIM, Lidar, and GIS projects will be more easily funded by the federal government. As programs like these are funded, BIM and GIS integrated technology will only increase in accuracy in the construction industry.

Technical Section 1: Making of the Terrain and Imagery Model Components

Introduction:

Technical Section 1 details the procedure for obtaining accurate terrain and ground imagery for an Infraworks model. The procedure was utilized in a case study of Frick Park in Pittsburgh, PA. In this section, one can find how to transform a 2D ground image into a 3D terrain surface using Infraworks.

Procedure:

(1) Use model builder to obtain USGS terrain data for Frick Park area.
(2) Use PASDA to obtain ground imagery.
(3) Accurately geolocate the ground imagery on the terrain
(4) Interactively geolocate the building Revit design models

Detailed Procedure:

1) In order to obtain USGS terrain data, the model builder function in Infraworks was utilized. One must select the proper area of the model extent (Image 1). It is recommended to keep the USGS terrain and imagery to the same size due to boundary errors that occur in Infraworks. After selecting the USGS area of Frick Park, one must confirm the selection and then the information is sent to Autodesk's cloud based service. In approximately five minutes, one should receive accurate USGS information of the area. In addition there is ground imagery included in the model. However, the ground imagery is Bing Map's satellite imagery. In this case PASDA fly over information was available for Allegheny County. The PASDA information was used over the Bing Map data because it produces a sharper image. As well the PASDA image was taken in the fall and shows less foliage which distorts the image.

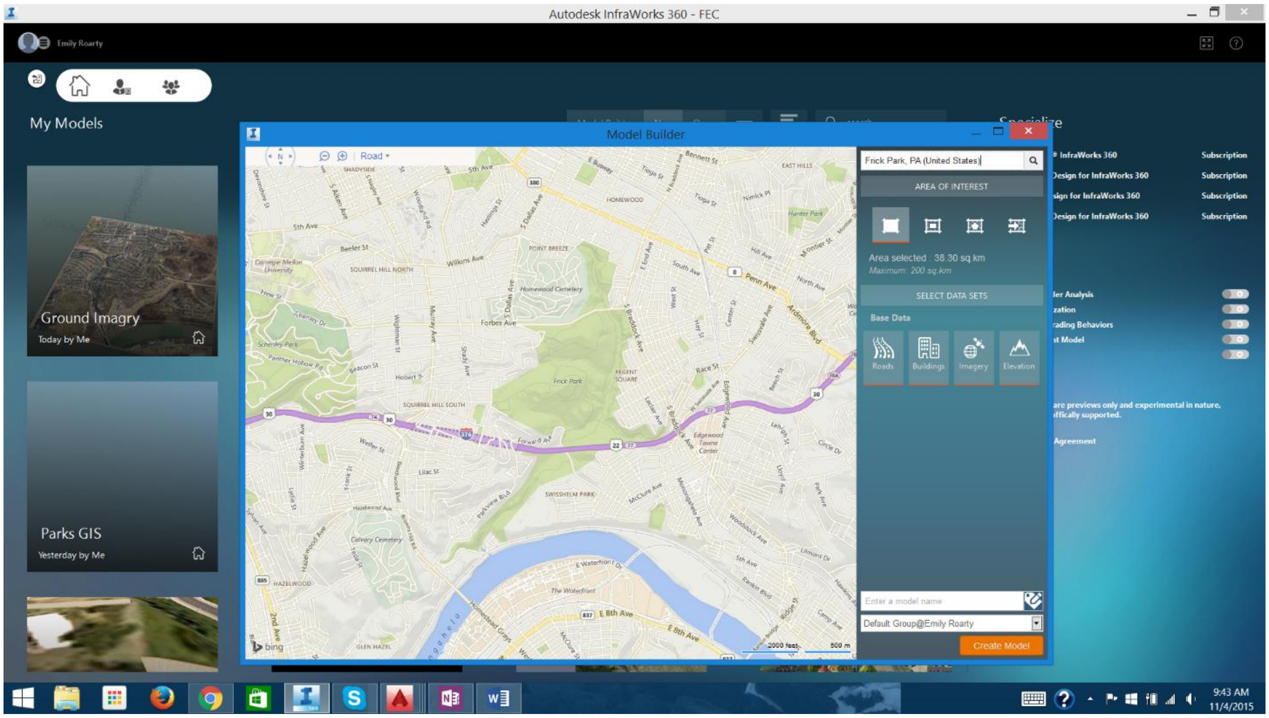

Image 1. Model Builder to obtain USGS terrain information.

2) Secondly I obtained the ground imagery, but using the tile index from the PASDA website. Begin by locating the tile that matches the terrain area. Zoom into the particular area and click on the right tile. A pop up box will indicate the imagery file to use (Image 2). Once you have the file name, locate the file in the list of files which are organized by when they were taken during the fly over (Image 3). Save this file (might take ten minutes because it is a high resolution raster file), so that one might import it into Infraworks later.

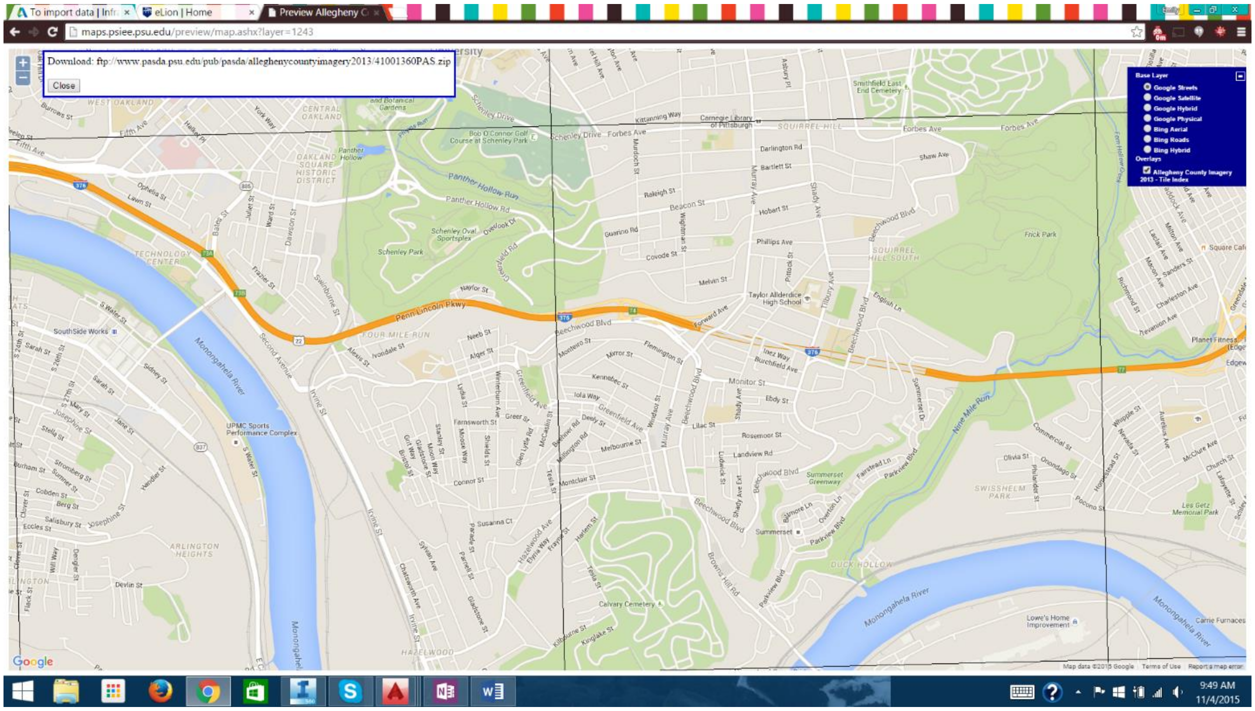

Image 2. File Index PASDA website to select correct ground imagery.

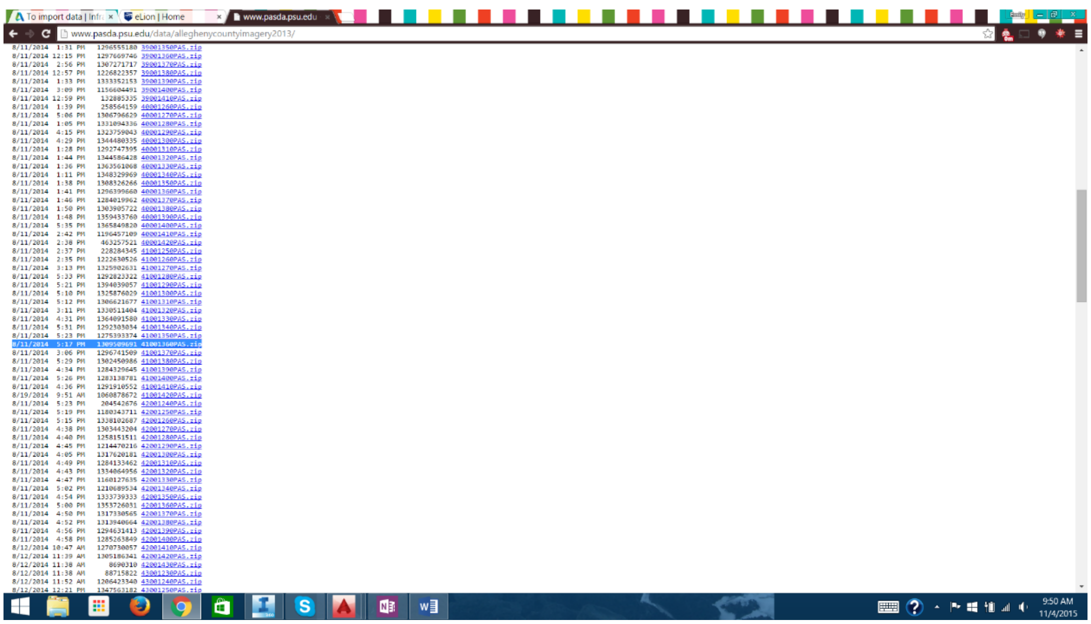

Image 3. The Tiles of Images organized at the time they were taken.

3) Now begin to import the ground imagery PASDA file on the 3D USGS information. Go back into Infraworks and import the PASDA file. The trick is to accurately geolocate the ground imagery, or one might receive boundary or coordinate system errors. In this particular case, the coordinate system for Frick Park was PA83-SF (Image 4). Make sure

that the ground imagery will clip to the model extent, which is a default setting for any ground imagery in Infraworks (Image 5) . Close and refresh the imagery and now the 2D PASDA image should be on a 3D USGS terrain surface.

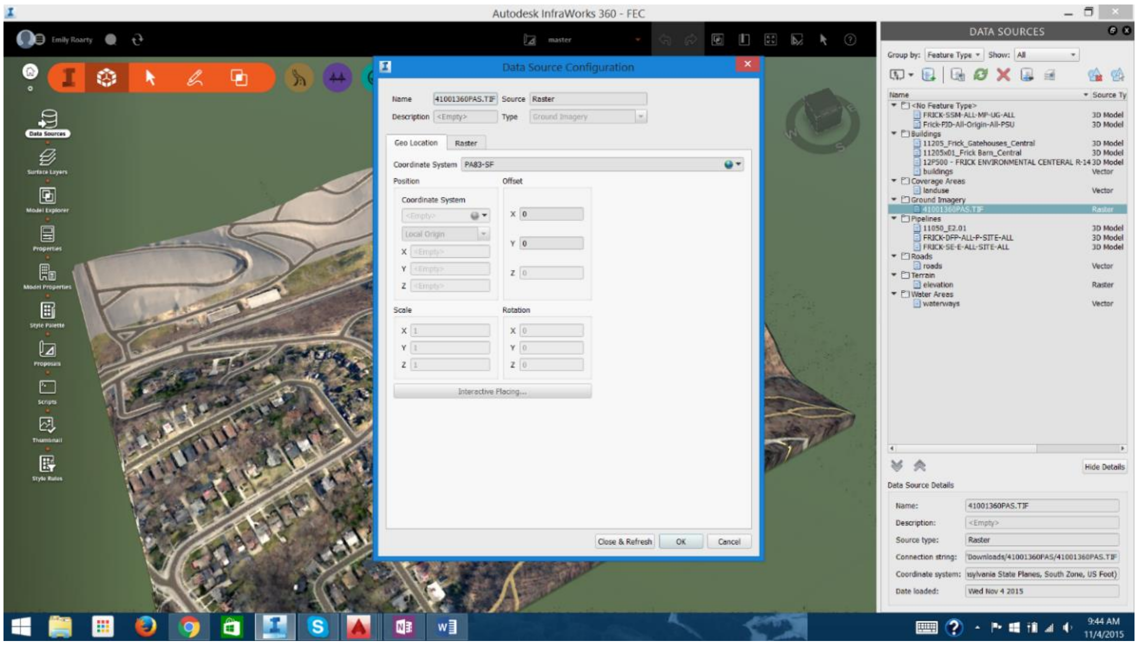

Image 4. Select the correct coordinate system for the ground image.

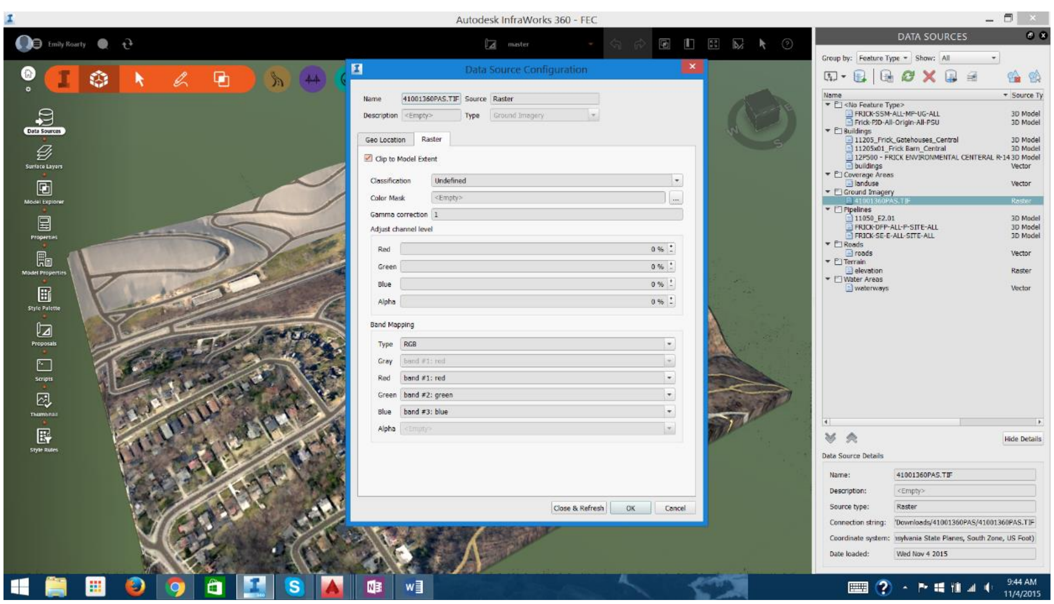

Image 5. Ensure that the ground imagery is clipped to the model extent.

4) The next step is to accurately geolocate the buildings on the terrain. In the Frick Park case, the buildings were modeled in a Revit file with a local origin. One can change the geolocation of the Revit files once the files are imported into Infraworks. The method used to create an accurate coordinate system for Frick Park was to use the PA83-SF and then use the interactive placement tool. The interactive placement tool allows one to use landmarks like the terrain and road to get the building into an accurate coordinate system. There are multiple ways in Infraworks to select the model; for example, center 2D, center 3D, and lower left front. Using the lower left front feature in the interactive placement tool was the most successful in geolocation the buildings.

   The buildings in the Frick Park model were geolocated using the roads, terrain, and pathways as a reference point. However, the pipelines utilized a grid system to accurately locate their placement. The placement of a grid on the terrain surface and the location of the pipelines is detailed in Technical Section 2.

Technical Section 2: Geolocation of Utilities

Procedure:

1) Import all models both building and utilities on to Revit Site model in Infraworks.
2) Make sure that all the models including the site are in the correct coordinate system.
3) Import the terrain and imagery files found in technical section one.
4) Geolocation of the terrain and imagery files so they match with Revit model
5) Delete the Revit Site model, just the site, not the buildings or utilities.
6) Then you should have a buildings and utilities geolocated on a USGS site.

Detailed Procedure:

1) Import all models both building and utilities on to Revit Site model in Infraworks.

   In order to have all the building models and site models on the same coordinate system it is imperative to locate all of the models on the same coordinate system. Even if the

existing Revit site model is not USGS terrain, it can be placed on USGS terrain using this method.

2) Make sure that all the models including the site are in the correct coordinate system.

   Next, to make sure the models are in the correct coordinate system by going into data sources and making sure that all the building and utilities models are placed in an accurate coordinate system, which will line up with the USGS terrain and PASDA ground imagery in technical section one.

3) Import the terrain and imagery files found in technical section one.
   Now to import the terrain and imagery files, one must import raster file from the local files saved on the computer. Autodesk Infraworks saves local files on the computer, so access the local model that was made in technical section one. Under the resources folder that is made automatically by the local Infraworks file, both raster files for the USGS terrain and PASDA model will be in the resources folder.

4) Geolocation of the terrain and imagery files so they match with Revit model
   When configuring the terrain and imagery files make sure they are in the same coordinate system as in step 2. This is important for all the buildings and the utilities to be aligned in the right coordinate system.

5) Delete the Revit Site model, just the site, not the buildings or utilities.
   The Revit Site model should appear layered on top of the USGS and PASDA layers.

6) Then you should have a buildings and utilities geolocated on a USGS site.

Appendix A:

Now all of the buildings and utilities should be geolocated on an accurate USGS site with PASDA imagery data. The following six images are the components of the case study model at Frick Park located in Pittsburgh, PA.

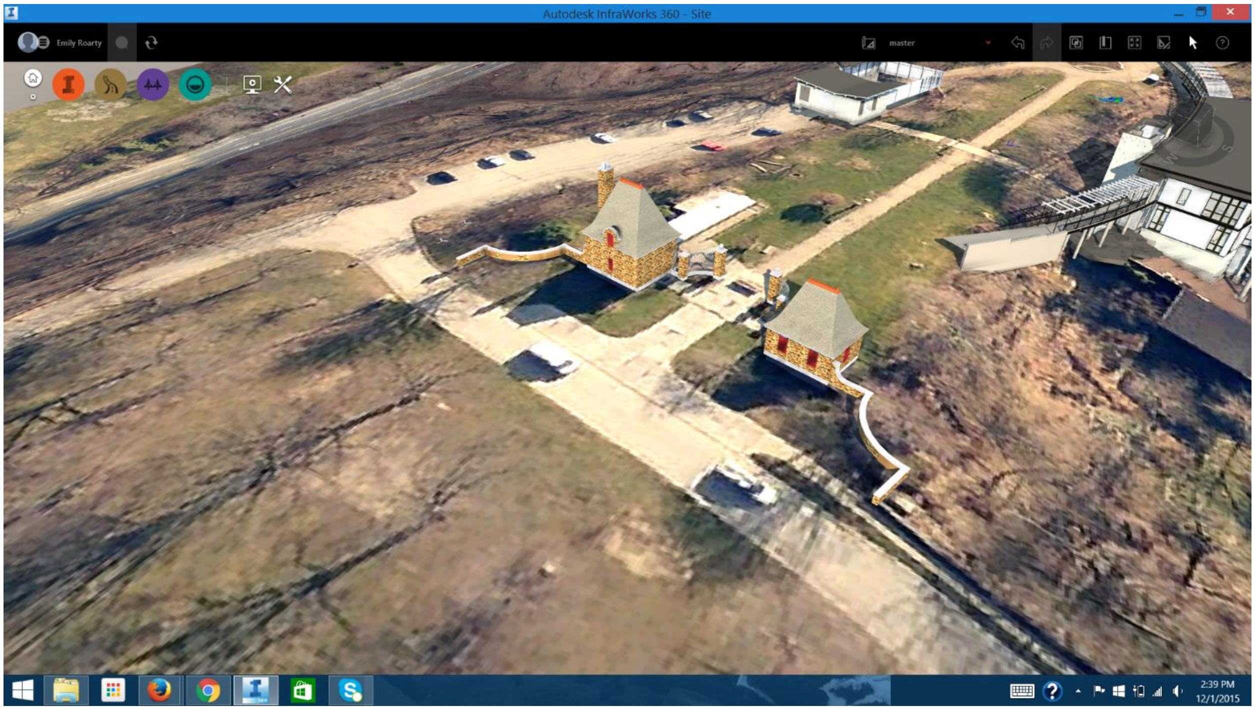

Image 1. Historic Gate Houses of Frick Park

Image 2. The new Frick Environmental Center

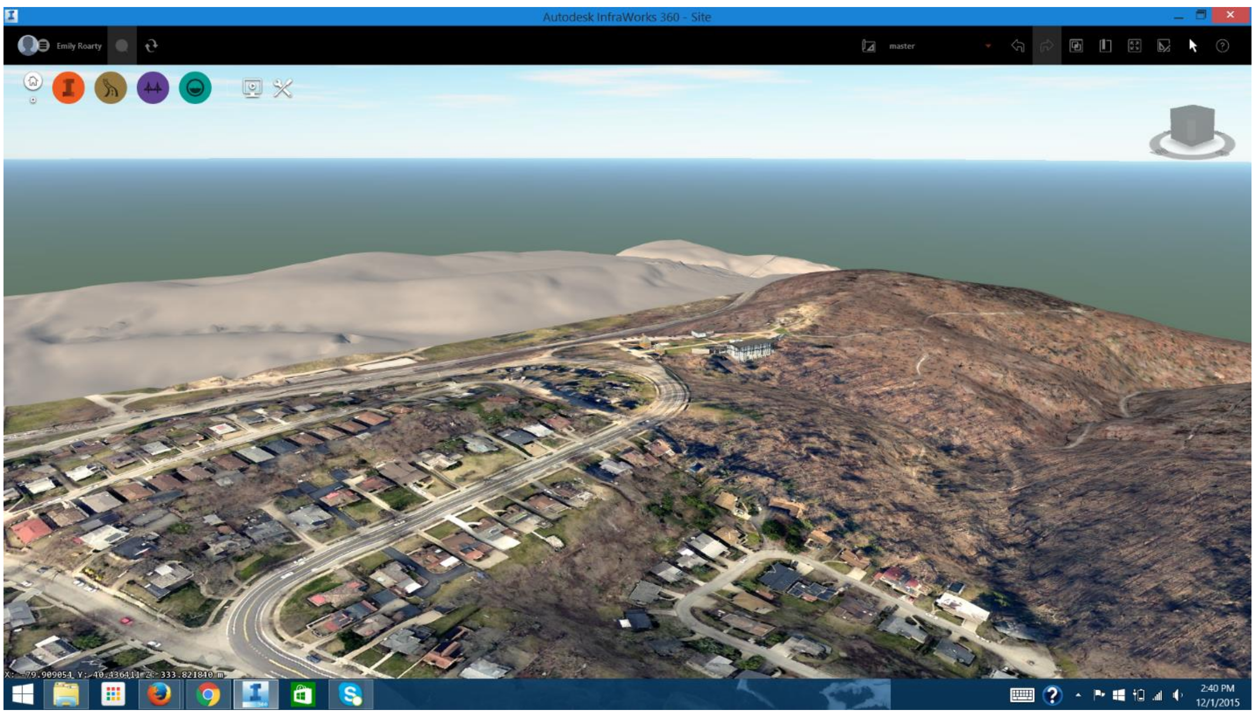

Image 3. An aerial image of the Frick Park site.

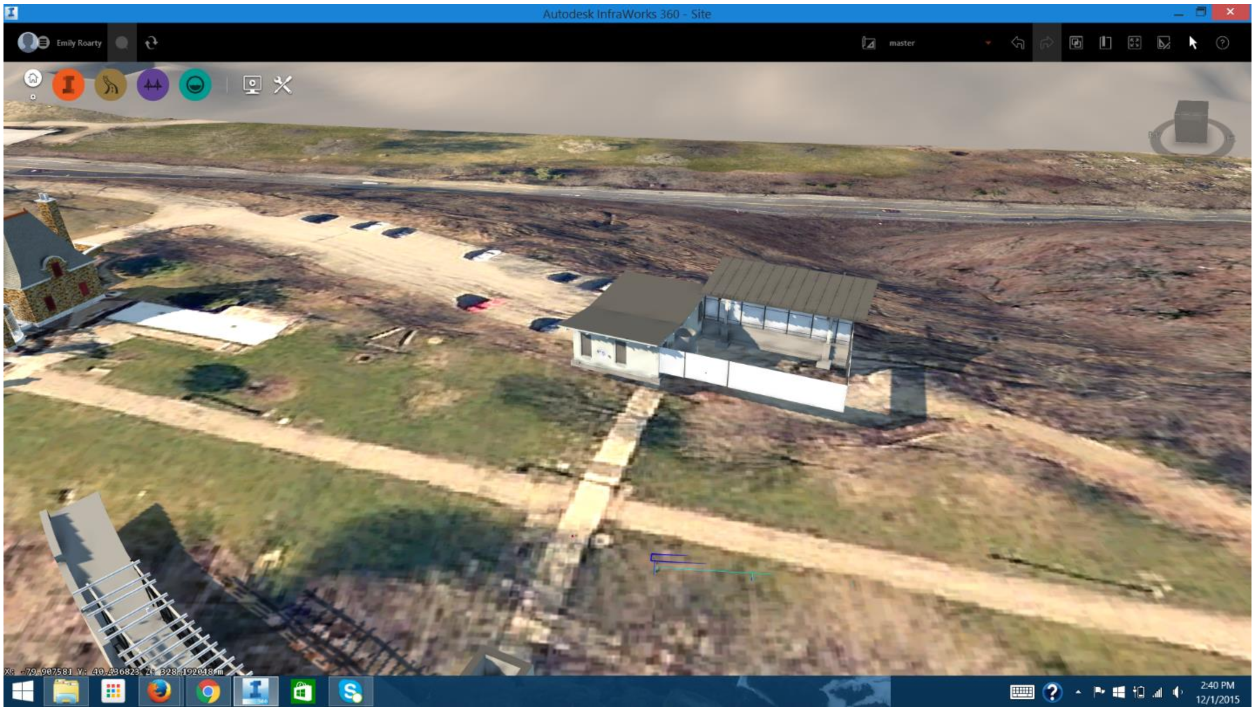

Image 4. The Barn building model located on the North of the site.

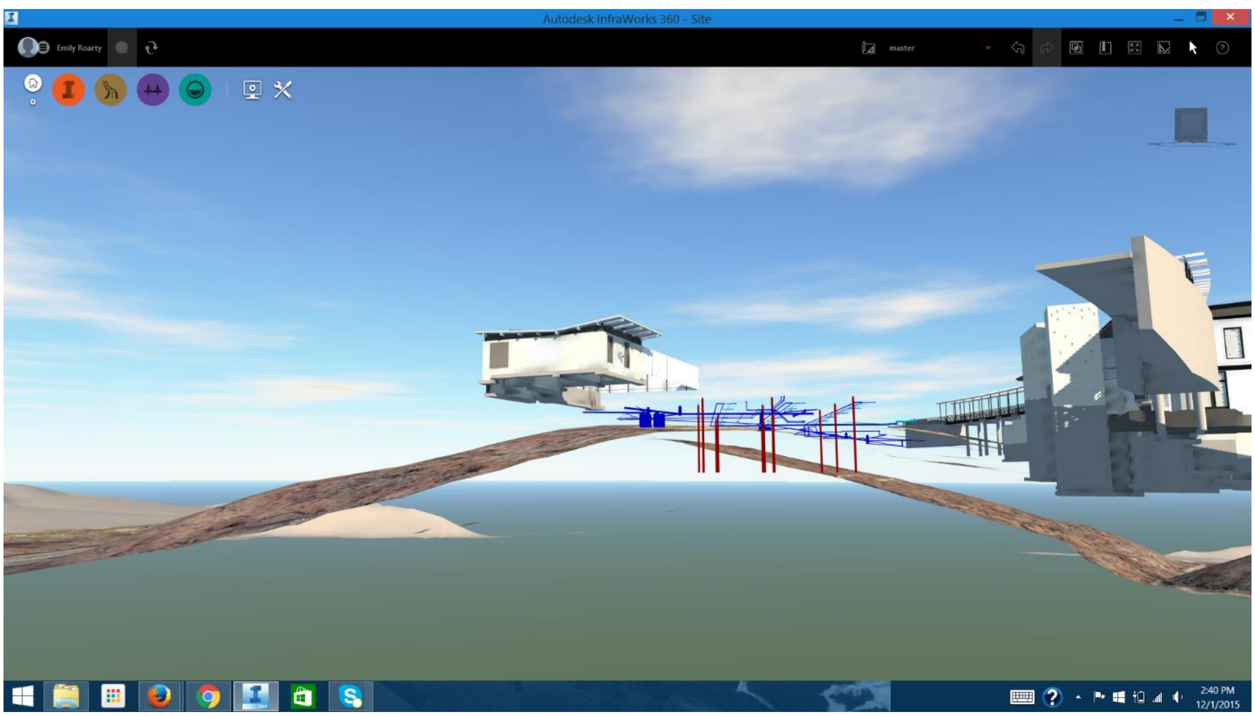

Image 5. The red vertical lines are the geothermal pipelines and the horizontal blue lines are the site plumbing.

Image 6. Another View of the pipelines on site.

Conclusion

To create an accurate BIM/GIS map, one has to obtain accurate terrain, data, and ground imagery. The next step is locate the utilities and building models in an accurate coordinate system. Once the models are in an accurate location, the map can be used on site as an official record of the utilities.

From a construction prospective, these models are valuable for safety, schedule, and financial reasons. In terms of safety, these maps could convert existing 2D drawings into 3D helping contractors to view the pipelines, preventing a pipeline from being hit. From a scheduler's perspective, a BIM/GIS map can prevent clashes in the pipelines that might take extra time to reroute. Finally for financial reasons, a BIM/GIS map is useful to prevent costly clashes from occurring.

REFRENCES

Bansal, V. K. "Use of GIS and Topology in the Identification and Resolution of Space Conflicts." *Journal of Computing in Civil Engineering J. Comput. Civ. Eng.* 25.2 (2011): 159-71. Web.

"BIM ThinkSpace." *'BIM ThinkSpace'* N.p., n.d. Web. 23 Sept. 2015.

"BIM vs. GIS." *BIM vs. GIS*. N.p., n.d. Web. 23 Sept. 2015.

Cheng, Jack C. P., and Yichuan Deng. "An Integrated BIM-GIS Framework for Utility Information Management and Analyses." *Computing in Civil Engineering 2015* (2015): n. pag. Web.

"Information Deficiencies in the AEC Industry." *The BIM Hub*. N.p., n.d. Web. 23 Sept. 2015. Kim, Hyunjoo, Zhenhua Chen, Chung-Suk Cho, Hyounseok Moon, Kibum Ju, and Wonsik Choi.

"Integration of BIM and GIS: Highway Cut and Fill Earthwork Balancing." *Computing in Civil Engineering 2015* (2015): n. pag. Web.